

This Page Is Inserted by IFW Operations  
and is not a part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

**IMAGES ARE BEST AVAILABLE COPY.**

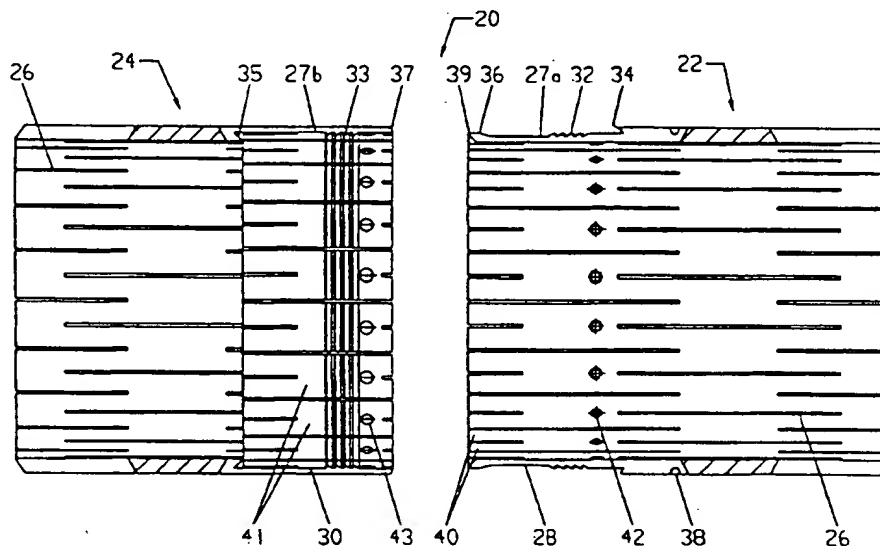
**As rescanning documents *will not* correct images,  
please do not report the images to the  
Image Problem Mailbox.**



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|  |  |  |  |
|--|--|--|--|
| (51) International Patent Classification <sup>6</sup> :<br>E21B 17/08, 43/10, 43/08  |  | A1   | (11) International Publication Number: WO 96/37681               |
|  |  |  | (43) International Publication Date: 28 November 1996 (28.11.96) |
| (21) International Application Number: PCT/GB96/01250  |  | (81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). |  |
| (22) International Filing Date: 24 May 1996 (24.05.96)   |  |  |  |
| (30) Priority Data:<br>9510465.9 24 May 1995 (24.05.95) GB   |  |  |  |
| (71) Applicant (for all designated States except US): PETROLINE WIRELINE SERVICES LIMITED [GB/GB]; Howe Moss Terrace, Kirkhill Industrial Estate, Dyce, Aberdeen AB2 0GR (GB). |  |  |  |
| (72) Inventor; and<br>(75) Inventor/Applicant (for US only): CAMPBELL, Alasdair [GB/GB]; 38 Bruce Crescent, Ellon AB41 9BW (GB).   |  |  |  |
| (74) Agents: McCALLUM, William, Potter et al.; Cruikshank & Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).  |  |  |  |
|  |  | Published<br>With international search report.<br>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.   |  |

(54) Title: CONNECTOR ASSEMBLY FOR AN EXPANDABLE SLOTTED PIPE



## (57) Abstract

A connector assembly (20) for connecting expandable slotted tubing (EST) (10) comprises tubular first and second parts (22, 24) for mounting on the ends of respective lengths of slotted tubing. The parts (22, 24) are themselves slotted (26). The free end of the first part defines a male portion (28) and the free end of the second part defining a female portion (30), the free ends of the parts being adapted to engage with one another and to permit expansion of the coupled parts in a corresponding manner to the tubing (10).

## CONNECTOR ASSEMBLY FOR AN EXPANDABLE SLOTTED PIPE

This invention relates to a connector assembly for use in connecting sections of expandable tubing, and in particular but not exclusively for use in the connection of sections of expandable slotted tubing (EST) as utilised in downhole applications in the oil and gas exploration and extraction industries.

Expandable slotted tubing (EST), such as described in WO93\25800 (Shell Internationale Research Maatschappij B.V.), may be used in various downhole applications. The tubing comprises lengths of tube which have been machined to create a large number of longitudinal slots. Thus, it is relatively easy to expand the tube radially outwardly by, for example, running a mandrel through the tubing. The expansion causes the slots to extend to create diamond-shaped apertures. The tubing is useful where it is desired to, for example, line a bore below a restriction without further reducing the diameter of the bore. Using conventional tubing the outer diameter of the tubing must, by necessity, be of smaller diameter than the restriction, to permit the tubing to be passed through the restriction. This reduction in the bore diameter has a number of significant effects, primarily in reducing the production capabilities of the bore. Using EST, the tubing may pass through a restriction into a reamed section of bore below the restriction. The tubing may then be expanded to a diameter larger than the restriction.

EST is supplied in lengths which are, at present, made up into a string by welding the lengths to one another. This is relatively time consuming and expensive and in many situations, for example in an off-shore operation in bad weather, it may be difficult to maintain consistent weld quality. Safety problems may also arise due to the high temperatures and exposed flames or sparks created by a welding operation. Further, in the event of a "mis-run", requiring the welded lengths of tube forming the EST string to be separated, the tubing must be cut, and the cut tubing

drilled holes.

The parts may be arranged with the respective slots aligned, though this is not considered essential to the successful expansion of the assembly.

5        Preferably, the parts define corresponding screw threads, such that the parts may be made up by relative rotation. Alternatively, the parts may be adapted to allow make up by stabbing in or most preferably by a combination of stabbing and rotation.

10        In a preferred arrangement fasteners are provided for securing the parts to one another; this prevents radial separation of the free ends of the parts when the connected tubing is expanded and prevents rotation of one part relative to the other. Most preferably, fasteners are  
15        located adjacent the free end of the outer female portion, to prevent the end from flaring outwardly on the tubing being expanded. The fasteners may be releasable, for example short screws for location in appropriate holes provided in the parts, such that the tubing may be  
20        separated in the event of a mis-run. The use of screws and the like, and the associated screw-holes, also provides a convenient means for ensuring that the parts are in a desired alignment.

25        Preferably also, the parts define corresponding threads and are also securable to one another by fasteners. Most preferably, the fasteners engage the female portion between the free end and the threaded portion thereof. This arrangement may be provided at any point in the slot pattern. In an alternative arrangement fasteners may also  
30        be provided to engage the male portion between the free end and the threaded portion thereof. With this arrangement it is preferred that threaded portions are located on the "nodes" of the parts, between the slot ends, that are not deformed by expansion of the assembly.

35        Preferably also, the portion of each part for engaging the free end of the other part includes an undercut ledge or groove, and the free end of the other part defines a

tubing (EST) 10. In its initial configuration, the tubing 10 is simply a length of pipe in which a series of longitudinal slots 12 have been machined (shown as tube 10a with slots 12a in Figure 2). Applying a radially outward force to the tubing wall, for example by passing a mandrel through the tubing, causes the tube to expand such that the slots 12a become diamond shaped openings 12b, as described in WO93\25800.

The tubing 10 is supplied in lengths suitable for transportation and handling and these are joined to one another on surface to create a tubular string. The connector assembly 20 as illustrated in Figures 3 and 4 of the drawings is used to connect such tubing lengths. The assembly 20 comprises a first part 22 and a second part 24, which are mounted on the ends of the respective tubing lengths. In this particular example the parts 22, 24 are adapted to be welded to the tubing ends. The parts 22, 24 are intended to expand in a similar manner to the tubing 10, and as such are provided with similar longitudinal slots 26.

The free end of the first part 22 is machined to form a male portion 28 and the free end of the second part 22 defines a corresponding female portion 30 adapted to receive the male portion 28, as will be described. Both portions 28, 30 carry corresponding screw threads 32, 33 such that the parts 22, 24 may be made up by relative rotation. The threads are located on the "nodes" 27a, 27b of the fingers 40, 41 formed by the slots 26, that is the areas between the slot ends which remain substantially undeformed following expansion of the assembly 20.

Each part 22, 24 also defines a respective undercut ledge 34, 35 for engaging the free end of the other part 36, 37, which is of corresponding form. The ledge 35 formed on the second part 24 defines a back angle and co-operates with a radially extending lip 39 on the free end of the first part 36. This serves to prevent the free ends of one part separating from the other part on expansion of

parts 22, 24 into alignment. The screws 44 are then secured in the holes 42, 43.

5 The desired number of tubing sections are connected in this manner to form a string and run downhole to the desired location within the bore. The tubing and the connector assemblies may then be expanded to the desired diameter. However, in the event of a mis-run, requiring the tubing to be withdrawn and disassembled, this may be achieved relatively easily by removing the screws 44, 10 unscrewing the first and second parts 22, 24 and then withdrawing the male portion 28 from the female portion 30.

15 It will be clear to those of skill in the art that the above-described embodiment is merely exemplary of the present invention, and may be subject to various modifications and improvements without departing from the scope of the invention.

female portion (30), to prevent the end from flaring outwardly on the tubing being expanded.

8. The connector assembly of claim 6 or 7, wherein the fasteners (44) are releasable.

5 9. The connector assembly of claim 8, wherein the fasteners are screws (44) for location in appropriate holes (42, 43) provided in the parts (22, 24), such that the tubing may be separated in the event of a mis-run.

10 10. The connector assembly of any of the preceding claims wherein the parts (22, 24) define corresponding threads (32, 33) and are also securable to one another by fasteners (44).

15 11. The connector assembly of claim 10, wherein the fasteners (44) engage the female portion (30) between its free end and the thread (33) thereon.

12. The connector assembly of claim 11, wherein fasteners are also provided to engage the male portion (28) between its free end and the thread (32) thereon.

20 13. The connector assembly of any of the preceding claims, wherein the parts (22, 24) define corresponding screw threads (32, 33) and the threads are located on the nodes of the parts.

25 14. The connector assembly of any of the preceding claims wherein the portion of each part (22, 24) for engaging the free end of the other part (24, 22) includes an undercut groove (34, 35), and the free end of the other part defines a tongue (37, 36) to locate in the groove (34, 35).

15. The connector assembly of claim 14, wherein at least one of said portions defines a back angle to engage with a

(10);

5 providing tubular slotted first and second parts (22, 24) on the ends of the respective tubing lengths (10), the free end of the first part defining a male portion (28) and the free end of the second part defining a corresponding female portion (30); and

coupling said male and female portions (28, 30) to connect the first and second tubing lengths (10).

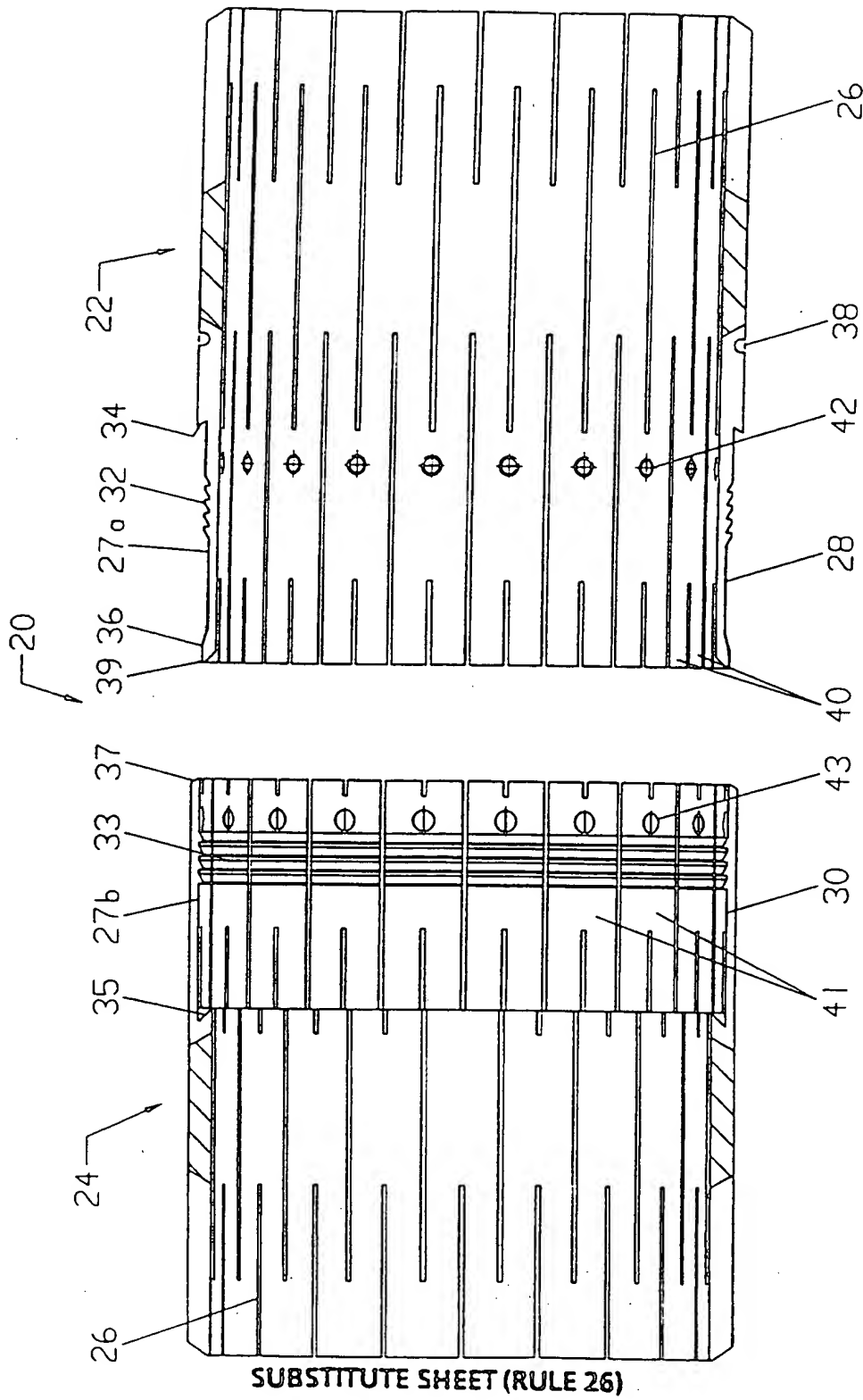


Figure 3

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/GB 96/01250

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 E21B17/08 E21B43/10 E21B43/08

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 E21B F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages                                       | Relevant to claim No. |
|------------|--|-----------------------|
| A          | FR,A,1 565 562 (RABUEL) 2 May 1969<br>see page 2, left-hand column, line 43 -<br>right-hand column, line 4<br>---        | 1,22,23               |
| A          | FR,A,2 359 358 (SOCIETE ANONYME FRANCAISE<br>DU FERODO) 17 February 1978<br>see page 2, line 21 - page 3, line 30<br>--- | 1,22,23               |
| A          | US,A,4 349 050 (BERGSTROM) 14 September<br>1982<br>see column 2, line 6 - column 3, line 6<br>---                        | 1,22,23               |
| A          | US,A,2 633 374 (BOICE) 31 March 1953<br>see column 3, line 67 - column 4, line 4<br>---                                  | 1,22,23               |
| A          | WO,A,92 01139 (NOBILEAU) 23 January 1992<br>see abstract<br>---  | 1,22,23               |
| -/--       |  |                       |

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- \*A\* document member of the same patent family

Date of the actual completion of the international search

24 September 1996

Date of mailing of the international search report

26.09.96

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax (+31-70) 340-3016

Authorized officer

Sogno, M